Next –Generation EOTDA Integration with Numerical Weather and Aerosal Models for Naval and Joint Service Applications

Douglas L. Westphal
Naval Research Laboratory
Monterey,
California 93943-5502
phone: (831) 656-4743, fax: (831) 656-4769, email: westphal@nrlmry.navy.mil

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LONG-TERM GOALS

This work unit is in the third year of a three year coupled rapid transition plan 6.2-6.4 development effort to transition aerosol prediction and EO tactical decision aid capability to the Fleet. This work is carried out jointly by NRL-Monterey and SPAWAR-SSC. The program will improve the components of the Target Acquisition Weather Software (TAWS), and link operational EO tactical decision aids (TDA's) to numerical weather prediction models. The NRL Aerosol Analysis and Predictions System (NAAPS) will be transitioned to the Fleet Numerical and Oceanography Center (FNMOC) at Monterey, CA for operational implementation. Specific elements of this 6.2-6.4 program (and the responsible personnel) include: (a) Develop and validate operational, diagnostic, and prognostic versions of the Navy Aerosol Analysis and Prediction System (NAAPS) for analysis of airborne dust loads (Westphal/NRL); (b) Modify existing radiative transfer codes to ingest NAAPS forecasts and produce practical products that depict the state of the atmosphere in terms of visibility and range (Reid/NRL; Tsay/GSFC; Westphal/NRL); (c) Improve the current marine target radiance models by developing new surface wake models and adding improved ship target models that include wake production (Doss-Hammel/SSC); and (d) Develop and improve operation of TAWS in maritime scenarios by utilizing numerical weather analyses and forecasts, and surface and satellite observations (Goroch/NRL).

This work unit addresses parts (a) and (b). The work unit goals are to address EOTDA and operational needs by using a predictive, global, operational aerosol model and radiative transfer models to produce global and regional forecasted fields of key radiative and visibility parameters in real time for use in weather forecasting and operational planning.

OBJECTIVES

The objective of this work unit is to rapidly transition NAAPS and related radiative transfer/EO prediction codes to 6.4/operations. This includes validation and documentation of the models, and development of a suite of products useful to the warfighter.

APPROACH

An existing global aerosol model (NAAPS) will be transitioned according to the conventions and procedures of FNMOC. This work includes porting the model to the NRL O2K, converting it to Open-

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MP, making the input-output compatible with FNMOC standards, writing documentation, conducting global and regional validation, developing a suite of useful products, and documenting the resource requirements. The product line will be developed with input from the users. It will include global and regional fields of radiative fluxes, optical depth, and visibility from aerosol fields as well as real-time and post-time metrics suitable for validation of NAAPS. The validation process will also include comparisons with TAWS transmission calculations.

WORK COMPLETED

NAAPS has been moved to the NRL O2K where it is currently running in parallel with the mother system. The conversion to Open-MP is near completion. We continue dialog with FNMOC on transitioning the products and on issues of coding conventions, documentation, validation, reporting, products, timeline, resource requirements, etc.

S. Gasso (University of Maryland), J. Reid (NRL) and S. Tsay (NASA/GSFC) have developed a fast method for calculating the bulk radiative fields for NAAPS fields. We have built interfaces between NOGAPS and MODTRAN (MODerate-resolution radiative TRANsfer model) to compute visibility, and between NAAPS and the Fu-Liou 4-stream radiative transfer model to derive shortwave and longwave fluxes. The interfaces are subroutines that produce the input parameter control files used by MODTRAN and the Fu-Liou radiative transfer codes. Version two of this software have been transitioned to NRL this year and is running in real time on the NAAPS mother system (SGI). This code will transition to the NRL O2K shortly. Refinements to the model are ongoing. Of particular interest is the development of products which estimate visibility at infrared wavelengths.

The standard inputs from NOGAPS and NAAPS in each 1 by 1 degree grid point are profiles of ambient temperature and moisture, and aerosol mass and concentration for three aerosol species (dust, smoke and sulfates). These are currently being validated against Moderate Resolution Imaging Spectroradiometer (MODIS) global optical depth fields as well as data from the over 50 Aerosol Robotic Network (AERONET) sun photometer sites scattered all over the globe.

We are preparing for a three-year re-run of NAAPS for the purposes of model validation. For this rerun, all source functions are being regenerated for the purpose of consistency.

RESULTS

The new radiative transfer post-processor (Forecast of Atmospheric and Optical Properties –FAROP) has been developed, tested and is running in real time at NRL Monterey. It calculates radiative and visibility parameters rapidly for the NAAPS forecasts of aerosol concentration that are produced every 6 hours during each 5-day forecast. An example of FAROP output for the Asian Theater is shown below in Figures 1 and 2. Web pages that present the NAAPS products as well as real time validation data are continuously being developed. Such web pages have been ported to the NRL SIPRNET and subsequently have supported Operation Iraqi Freedom.

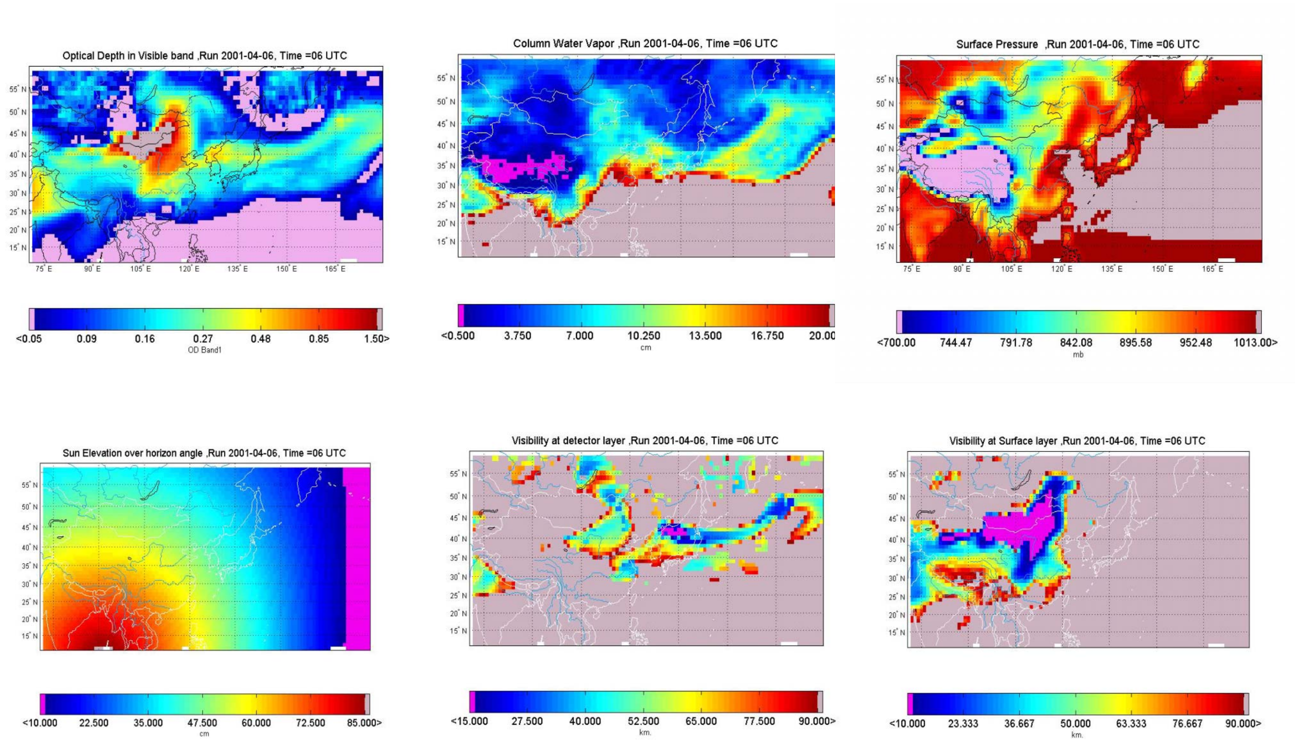


Figure 1. Example of Forecast of Atmospheric and Optical Properties (FAROP) output files. Upper-left: optical depth; middle: column water vapor, right: surface pressure; lower-left: sun angle; middle: visibility at 20,000 ft.; left: visibility at surface.

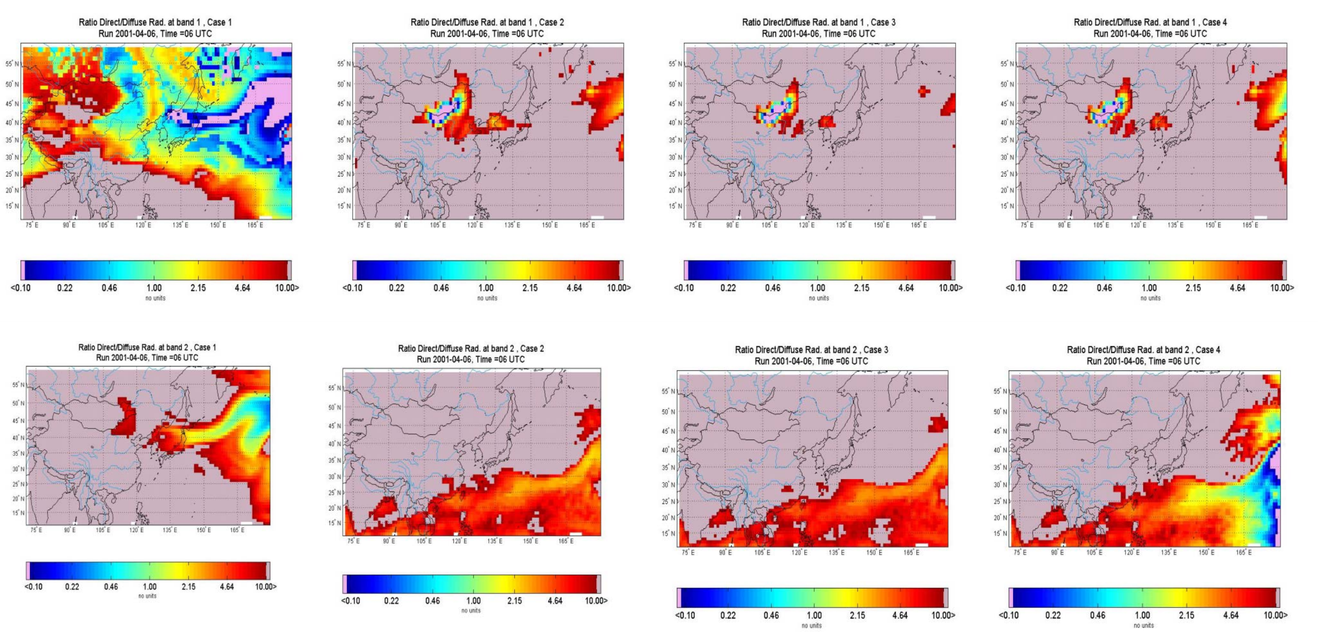


Figure 2. Example of FAROP estimate of ratio of direct to diffuse radiation in the visible (top row) and infrared (bottom row) for four nominal viewing geometries.

The models and products developed through this program will have considerable impact on estimates of EO propagation, operations, and weather prediction. The current user-specified aerosol type in TAWS will eventually be replaced by the predicted values from NAAPS. The current forecast products are currently available on the SIPRNET, and are aiding decision-making for naval activities in Iraq, carrier operations in other parts of the world, and port entry (the latter having been delayed by dust storms in the past.)

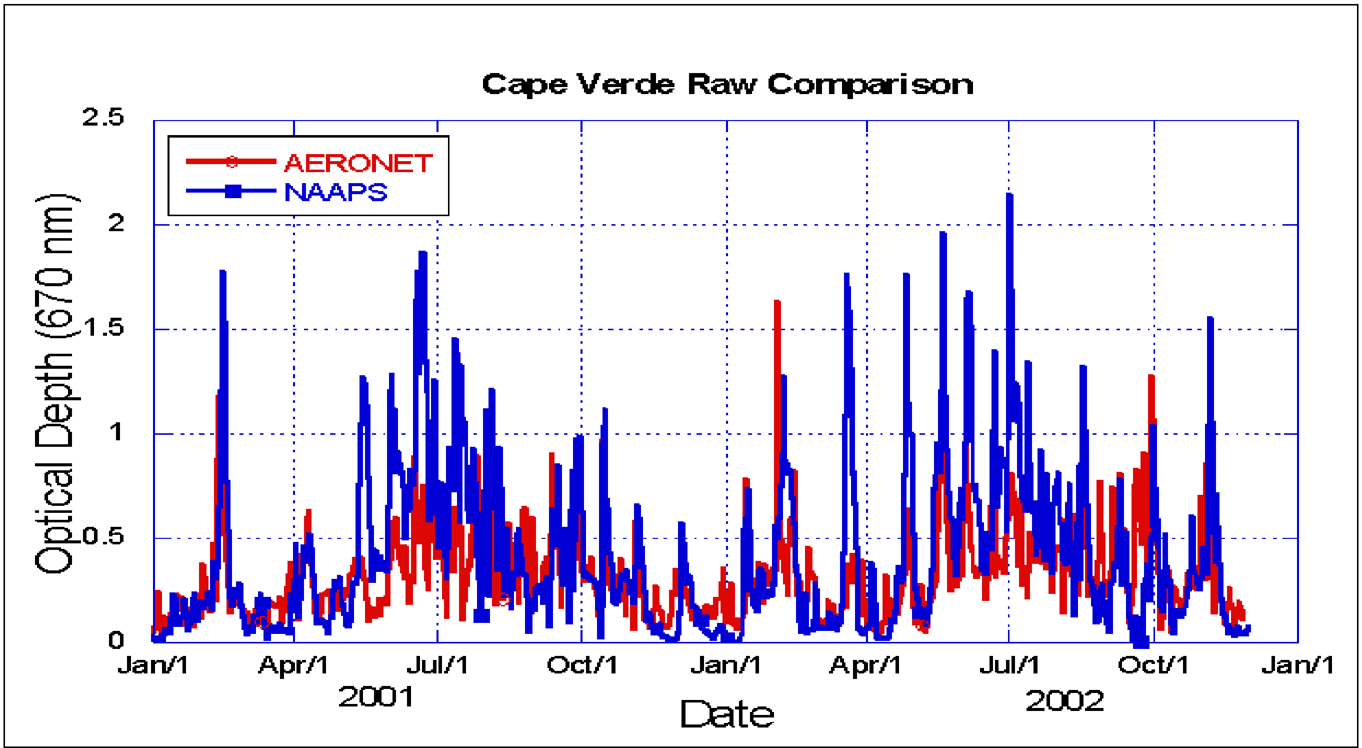
Validation studies are ongoing. Examples of results of such studies are presented in Figure 3. Here, Sun photometer optical depth data for Cape Verde are presented for the years 2001 and 2002 (for comparison, the mean is subtracted and all data are divided by the standard deviation in the lower image, mean bias is +30% for NAAPS). Clearly, NAAPS captures the timing and relative magnitude of Saharan dust storms well, both seasonally and for individual events.

TRANSITIONS

Simultaneous work is ongoing in the 6.4 component of this RTP to transition NAAPS and FAROP to operations at FNMOC.

RELATED PROJECTS

The NRL 6.1 base *Atmospheric Physics*, NRL 6.2 base *Improved COAMPS Land Boundary Layers* (includes COAMPS aerosol modeling) and NRL 6.2 *Advanced Moist Physics Modeling* use NAAPS data and products and the satellite retrievals for investigations and validation. The ONR 6.2 *Atmospheric Aerosol Characterization* will also use NAAPS simulations for high-energy laser research. This project utilizes the products of the ONR 6.2 project *Aerosol Microphysics and Radiation*.



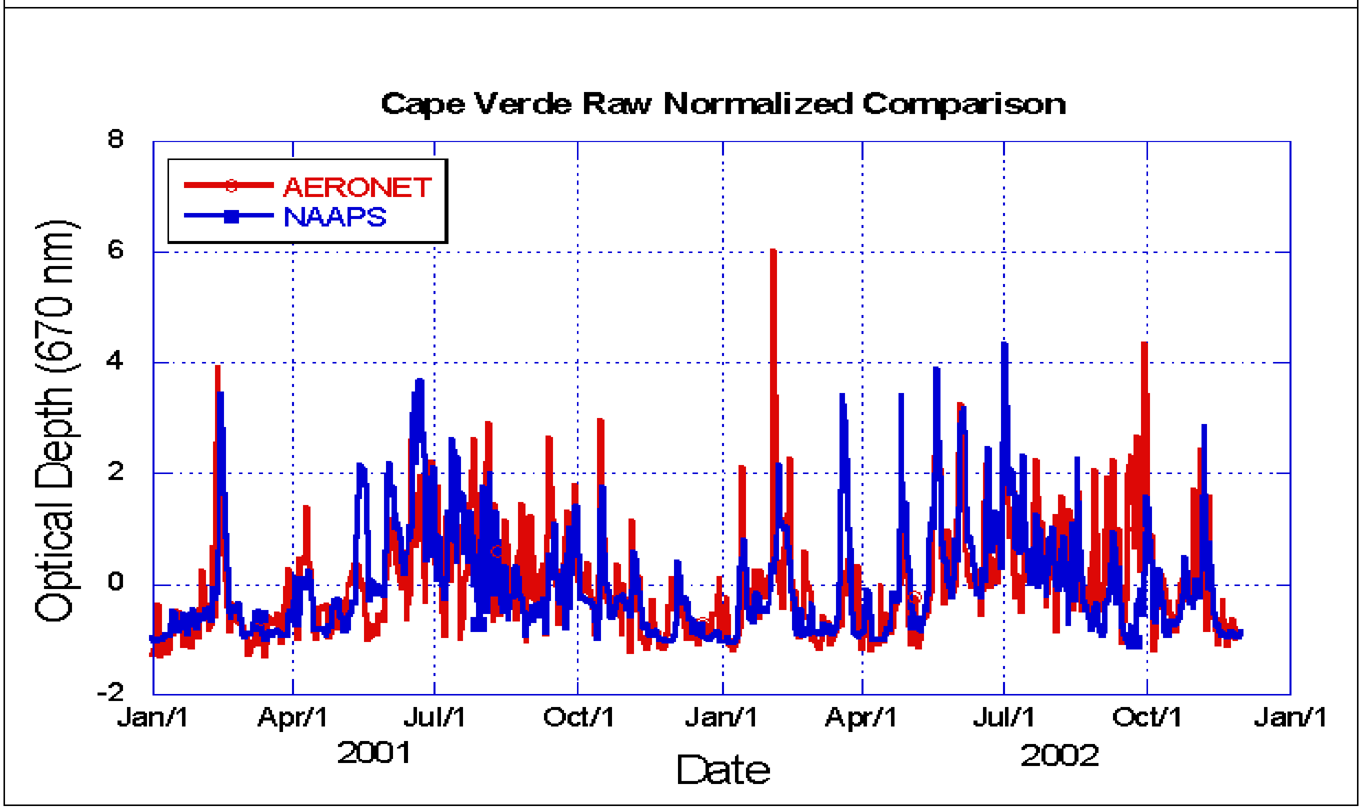


Figure 3. Time-series of dust optical depth at Cape Verde from AERONET Sun Photometer data and the NAAPS dust output product. Upper chart is raw optical depth comparison for the years 2001 and 2002. Lower chart is the same as upper, but with data mean subtracted and divided by standard deviation.